General public exposure to LTE in an urban environment

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Introduction

Assessment of exposures from emerging wireless network technologies is a priority in the research agenda of WHO. One of the newest wireless technologies is called LTE (Long Term Evolution) [1]. LTE is marketed as the fourth generation (4G) of radio technologies. Procedures for radio-frequency (RF) exposure measurements in the vicinity of base stations have been developed and standardized [2] but assessment of exposure to electromagnetic fields of emerging wireless systems such as LTE is missing.

The purpose of this study is to assess experimentally, for the first time to our knowledge, in-situ LTE base station exposure in a real urban environment (Stockholm, Sweden). A range of typical LTE exposures is provided and compliance with the ICNRIP guidelines for general public exposure is checked.

Materials and Methods

A commercial LTE network is deployed in the urban environment of Stockholm. Target values for the downlink peak data rates of LTE systems range from 10 Mbit/s up to 300 Mbit/s. In December 2009, world's first publicly available LTE-service was started in Stockholm, Sweden. Two LTE channels are present: at 2660 MHz (channel bandwidth of 10 MHz) and 2630 MHz (channel bandwidth of 20 MHz). RF electromagnetic-field measurements in the band 80 MHz – 6 GHz were performed at 30 different locations with a spectrum analyzer (noted as narrowband measurements). In order to compare base station exposure of different sources, these measurement locations were *randomly* selected, spread over Stockholm: 27 outdoor locations and 3 indoor locations were selected.

The measurement setup consisted of tri-axial Rohde and Schwarz TS-EMF Isotropic Antennas (frequency range of 80 MHz – 6 GHz) in combination with a spectrum analyzer (SA) of type Rohde and Schwarz FSL6. Current wireless RF sources are mainly operating in the frequency range of 80 MHz up to 6 GHz. After allocating the present signals by a spectral survey, these signals were measured more in detail. The narrowband measurements were executed during daytime at weekdays.

It is very important to specify and determine the correct SA-settings settings. The optimal settings to check compliance of LTE signals with the ICNIRP guidelines, are determined according to [3]. After investigations, we obtained the following optimal settings to perform exposure assessment of LTE: rms (root-mean-square) detector, resolution bandwidth RBW = 1 MHz, sweep time SWT = 20 s, and appropriate selection of the frequency span e.g., 50 MHz. These settings have been determined and tested in-lab and in-situ.

Results

Figure 1 shows the LTE exposures and total field values for the 30 measurement locations. LTE exposures range from 0.02 to 0.8 V/m (except at location 23, where LTE exposure was below the sensitivity of the measurement equipment). We define the exposure ratio as the ratio between the maximal measured field value for the considered signal over 30 locations and the corresponding ICNIRP reference level for the electric fields (thus ratios smaller than 1 satisfy the ICNIRP guidelines). The exposure ratios for LTE range from 0.0004 – 0.012 at the locations where LTE is measured. The mean LTE exposure equals 0.2 V/m.

All measured electric-field values in Stockholm satisfy the ICNIRP guidelines. The maximal *total* field value equals 2.6 V/m, this is 17 times below the ICNIRP guidelines. The exposure ratio varies between 0.002 and 0.051 for the different individual RF signals (20 to 500 times below the ICNIRP guidelines for electric fields). The average of the total values for all locations equals 1.1 V/m. The highest electric-field value was measured for the GSM900 signal (2.1 V/m). The highest value for E_{avg} is also due to the GSM900 signal and equals 0.7 V/m. The maximal measured field value for the LTE signal was 0.8 V/m (about 80 times below the ICNIRP reference levels for electric fields).

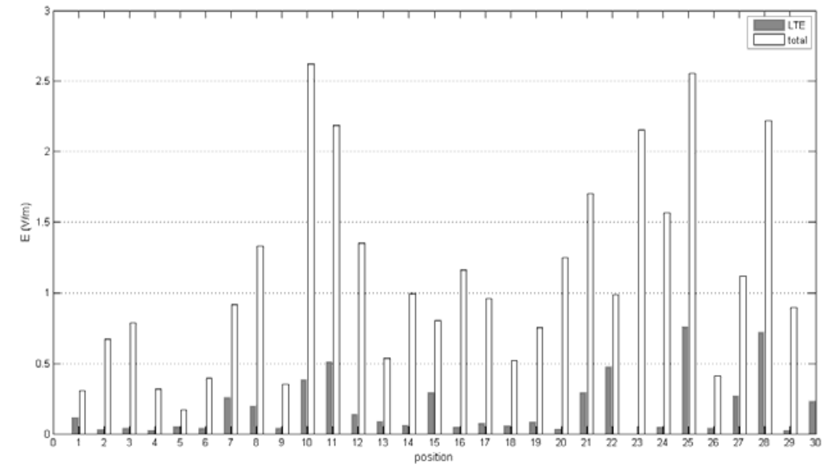

Figure 1: LTE and total exposures at30 locations in Stockholm.

At all positions except location 6 (in the neighborhood of a broadcast transmitter, here FM and DVB-T are dominant), the contribution is mainly due to GSM and UMTS-HSPA (High Speed Packet Access) as these technologies are most used nowadays in urban environments. The average (*AC*) power density contribution is the highest for the GSM900 (35.6 %), GSM1800 (26.2 %), and UMTS-HSPA (26.4 %) signals. The LTE signal was measured at all the selected measurement locations except at one indoor position (position 23 in Fig. 1), where the LTE signal level was below the sensitivity of the measurement equipment. The average contribution of the LTE signal equals 4.1 %, the maximum contribution 23.2 %.

Summary and Conclusions

LTE is present everywhere in the city of Stockholm but the contribution to the total exposure is limited to about 4 % on average. RF exposure in Stockholm is dominated by GSM and UMTS-HSPA. Future research will consist of the investigation of the temporal behavior of LTE signals and the influence of usage traffic. Also narrowband measurements at more locations and other environments will be part of future research using the proposed methodology, once LTE networks are deployed elsewhere.

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